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obtain an evenly illuminated field on the screen. Under such circumstances it is necessary to remove the sub-stage condenser from the microscope, and substitute for it a plano-convex lens of some three to four inches focus, placed close to the object. The instrument must then be moved close to the large concentrating lens in the shutter, when it will be found that objects, even as large as ¾ inch in diameter, are evenly illuminated.

ON THE SYSTEMATIC EXAMINATION OF OBJECTIVES FOR THE MICROSCOPE, WITH A CONVENIENT FORM FOR RECORDING RESULTS.

BY GEO. E. BLACKHAM, M. D., F. R. M. S.

The microscopist dealing, as he necessarily does, with minute quantities is peculiarly liable to be aided or hindered by slight differences in the quality or qualities of the instruments with which he works, for, while it is doubtless true that an expert can do very fair work with instruments of only moderate quality, and the tyro can not do first-class work with any instrument, even of the most superior excellence, it is also true that, other things being equal, the better the instrument used the better and more reliable will be the results obtained, and that the best work can not be done, even by the most expert workers, except with the best instruments. This being the case the comparison of instruments must always, if properly, skillfully and fairly done, be of value to the worker—who may thus be enabled to select such as shall be best fitted for the work he may have in hand. The most important optical part of the microscope, and also the part most subject to variation of qualities, is the objective. Our ordinary methods of describing these seem to me to lack precision; for instance, we often see the recommendation to beginners to purchase a stand and a one inch and one-fifth inch objectives. Now the one-fifth may be said to be a cheap "student's" objective, and on referring to the Catalogue of some maker we may find it thus described: No. . . ; student's series; one-fifth; ap. 100°; non-adj.; price, $15.00, in another we may find: No . . ; student's series; one-fifth; ap. 85°; non-adj.; price, $12.00. How is the student to choose between them? The descriptions are utterly insufficient to enable him to compare them. Which glass has the greatest resolving power, which the flattest field, which the longest working distance, and which the greatest amplifying power? Of course if objectives were all truly named the last question would be answered as all one-fifths have the same amplifying power, viz: x50 at 10 inches from optical centre of the objective, but such is not the case.

In order to meet this requirement and answer these questions, I have elaborated a system of examination and prepared a blank form for recording the results which, I think, gives at a glance most, if not all, of the points necessary in the comparison of objectives.

The first column gives the record number for convenience of reference; the second the owner's name, and the third the name of the maker, and the year in which made. This latter is important as in these days of rapid improvement in microscope construction it would be obviously unfair to compare an objective made five or even three years ago, with one of same nominal power made this year without stating the fact. The rext seven columns, (No. 5 to 11, inclusive), give the description of the objective as obtained from the maker, viz: its price, (the price is given in the published copy as a matter of justice to makers, whose cheap objectives appear in the list, as it would be unjust to compare the work of a cheap objective with one of same nominal power, costing twice or three times as much, without making the fact apparent); designation; adjustment for cover (if any); dry or immersion; equivalent focal length, and its aperture in air, water or balsam. The remaining columns show the results of examination. The first group shows the extreme angle for the *admission of light* from the centre of the field, measured in air, water or balsam; the next group the extreme angle for *perfect definition*, also measured in air, water or balsam. This latter value is usually, though not always, less than the extreme angle for admission of light, and the difference between them, which is sometimes very considerable, shows the extent to which the nominal aperture of the lens could be profitably reduced by diaphragms, as proposed by Dr. Ryston Pigott. The next column gives the nominal amplifying power, that is the amplifying power of the objective alone at 10 inches from the optical centre of the objective; providing its nominal equivalent focal length was correctly given, this would be for a one-half inch x 20, for one-fifth x 50, etc., etc. The next column shows the actual amplifying power measured at 10 inches from surface of front lens of the objective. It would have been more absolutely accurate to measure from the optical centre, but the exact position of this point could not be ascertained without a knowledge of the formula on which the objective was constructed, and in lenses possessing adjustment the position of the optical centre varies with every movement of the adjustment. The front surface of the front lens being a fixed and easily determined position, and the results obtained by using it, differing but slightly from those obtained by using the true optical centre it was selected as, on the whole, the best position from which to measure the ten inches. The method of measurement has been to compare the image of a Rogers stage micrometer with that of an eye-piece micrometer placed exactly ten inches from the front lens, both micrometers being magnified by means of a Bausch and Lomb (Gundlach) periscopic eye piece, in which the field lens is placed within the focus of the eye lens and the eye piece micrometer placed below the field lens and in the focus of the eye piece as a whole. The ordinary Huyghenian eye piece will not answer for this kind of work. The actual and nominal amplifying powers of objectives are often very closely identical, and where variations occur the actual will sometimes be found in excess of the nominal and *vice versa*. I am led to believe that as a rule, makers honestly strive to name objectives correctly. The next column gives the frontal distance of the objective, that is the distance from front of lens or of brass setting to the object; and the next column gives the working distance, which is frontal distance minus thickness of cover glass (in all cases here being .002 inch—the same cover being used with all objectives.) The next column gives the clear aperture of front lens—that is, the diameter of the light spot seen when the objective is reversed—held with front lens toward the eye and the posterior combinations pointed at a brightly illuminated white surface, such as a sheet of paper. The clear aperture of the front lens is always much less than the diameter of exposed front surface which is free of the setting.

The next column gives the diameter of field which often varies considerably with the objectives of same nominal power. The next column shows the flatness of field, indicated by an arbitrary standard of 1 to 6—the latter representing an *absolutely* flat field which I have not yet found in any objective I have examined. The next column shows the chromatic correction. I have been unable to devise any numerical method which would fairly represent the quality, and have been forced to content myself with such vague notes as "slightly under," "slightly over," etc.

The next two columns give the number of the diatom on Möller's balsam mounted "*probe platte*" clearly and fully resolved by the lens with light from lamp and mirror, and the number of lines per .001 inch as determined by Prof. Morley's measurements. The next two columns, the number of the diatom on same "*platte*" which could be just glimpsed under same conditions, and the number of its striae per .001 of an inch. The last column is for remarks.

It is of course understood that many of the results given would vary with different eye pieces, but all, except the actual amplifying power, have been obtained with Tolle's ½ inch solid eye piece, the field of which is small enough not to be affected by the size of the tube of the microscope.

I present herewith the results of my examinations of forty objectives of various makers. It was intended that the table should be as complete as possible, but at least two important omissions have been discovered as the work progressed—

1st.—The diameter of the exposed face of front lens should have been given.

2d.—The number of the diatom on the Möller platte resolved with direct *central* light should also have been recorded.

There are probably other points which have been overlooked, but the table is submitted as an earnest and honest endeavor to remove the examination of objectives from the domain of mere opinion to that of carefully ascertained and accurately recorded *fact*. The attempt has been to ascertain and record the details of the best performance of each objective for itself rather than to express an opinion as to its excellence or defects as compared with some standard, ideal or actual, and it is hoped that, not only these records but more especially the *method* may prove of interest and possibly of service to users and makers of objectives.

In conclusion I wish to express my thanks to the owners, dealers and makers who have kindly placed objectives in my hands for examination, and my regret that my limited leisure has prevented me from making the present exhibit more complete by including the work of other makers.

OBSERVATIONS ON LERNEOCERA CRUCIATA.

BY D. S. KELLICOTT.

Mr. A. M. Norman, in the *Zoologist* of London in 1864, remarks as follows: "Little has been done, as yet, in Great Britain among the external parasites of fish. The only work that treats of them is Dr. Baird's 'History of the British Entomostraca.'" It is fifteen years since the statement appeared, and yet it has